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COMPARATIVE GROWTH OF MACROBRACHIUM ROSENBERGII RAISED ON FOUR DIFFERENT DIETS

Report No 85-192-K

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ABSTRACT

Growth and survival of Macrobrachium rosenbergii raised on four different diets were compared to determine which diet would result in satisfactory growth in our indoor artificial culture system. The four diets tested consisted of chick starter, part chick starter and part prawn grower, prawn grower, and part prawn grower and part fish flesh. The protein content of the first three diets was 24, 32, and 40%, respectively, while that of the latter diet was not determined. The growth rates as well as the mean weights attained by the prawns on the four diets were significantly different from each other and, in the case of the first three diets, increased with protein content of the feed. The part prawn grower and part fish flesh diet resulted in the best growth. Diet was not found to have a significant effect on survival.

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EXECUTIVE SUMMARY

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The tropical freshwater prawn Macrobrachium rosenbergii has been identified as a candidate for development in thermal aquaculture as a waste heat usage scheme based on its culturability and market potential. In our first attempt at raising this species the growth and survival of the prawns were unsatisfactory and this was attributed to an inadequate diet. The objective of this study then was to identify a diet that would result in satisfactory growth and survival of prawns under our culture conditions in indoor artificial systems.

The diets tested were chick starter, part chick starter and part prawn grower, prawn grower, and part prawn grower and part fish flesh. The protein content of the former three diets was 24, 32, and 40%, respectively. The protein content of the latter diet was not determined.

The growth rates and mean weights of the prawns raised on the four diets were significantly different from each other and, in the case of the first three diets, increased with protein content. Growth on all four diets exceeded that obtained in our first experiment on this species and the part prawn grower and part fish flesh resulted in the best growth. Although this diet resulted in satisfactory growth which was comparable to that reported in other studies on the diet of Macrobrachium rosenbergii, it was substantially lower than that obtained in Malaysian ponds of good water quality and ample food indicating that further enhancement may be possible.

Survival was not significantly affected by diet.

P.S.

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TO: Mr. F.J. Kee
Director of Research

COMPARATIVE GROWTH OF MACROBRACHIUM ROSENBERGII RAISED ON FOUR DIFFERENT DIETS

1.0 INTRODUCTION

The tropical freshwater prawn Macrobrachium rosenbergii has been identified as a candidate for thermal aquaculture in a waste heat usage scheme on the basis of its culturability and market potential (Ontario Hydro Research Division Report No 84-56-K).

In the first experiment conducted on Macrobrachium rosenbergii in our laboratory unsatisfactory growth and survival were obtained (Ontario Hydro Research Division Report No 84-458-K and No C85-12-K). It was suggested that the lack of weight gain was due to a deficient diet which may also have contributed to the low survival. The postlarval prawns were fed a diet of chick starter (79% by weight) bound by agar (10%) and gelatin (10%) to which the amino acids (1%) arginine, phenylalanine, leucine and isoleucine had been added. The protein content of the feed was approximately 24%.

Chicken broiler starter is the main feed used by prawn farmers in Hawaii and specialized diets developed for the species are generally modifications of this feed (Corbin et al. 1983). The use of broiler starter feed originated with Fujimura's (1974) early rearing trials which showed that freshwater prawns could be cultured commercially in naturally productive large earthen ponds using only broiler starter as the staple supplemental feed. A study conducted by Stanley and Moore (1983) on earthen culture ponds indicated that the application of commercial feeds of varying protein content (27% to 44%) does not result in significant differences in the average weight gain of the prawns. One explanation they offered for the lack of growth advantage observed with the improved feeds was that the diets all met the nutrient requirements of the prawns. An alternative suggestion was that with low standing crop and adequate natural productivity application of improved feeds is superfluous.

In indoor artificial culture systems, whether tank systems or concrete pool systems, the feed must be adequate to promote satisfactory growth since natural productivity is lacking. Unfortunately, differences in diet preparations, environmental conditions and stocking densities used by the various researchers who have studied prawn diet makes the comparison and evaluation of their results difficult (New 1976).

Boonyaratpalin and New (1982) who used pelleted diets with protein content of 15, 25 and 35% as well as broiler starter in rearing studies in concrete ponds, found that the growth, production, survival and feed conversion of the prawns raised on the four diets were not significantly different. They attributed their success in rearing prawns equally well on all four diets to natural food present in non-earthen ponds fertilized with the pelletized feed. Fujimura and Okamoto (1970, in Balazs and Ross 1976) obtained similar results in experiments conducted in large volume tanks using diets with 18, 24, 24 and 40% protein content. Stanley and Moore (1983) suggested that Boonyaratpalin and New (1982) and Fujimura and Okamoto's (1970) results may have been affected by unquantified natural production or due to differences in the test diets other than protein level.

In contrast, Balazs and Ross (1976) who cultured prawns in outdoor tanks on water-stable diets of 15, 25 and 35% protein content found that increasing levels of protein produced larger animals.

The objective of this study was to identify a diet that will result in satisfactory growth and survival of prawns under our culture conditions in indoor artificial culture systems. The chicken starter ration was compared to three diets with higher protein content to determine whether the provision of improved diets would enhance the growth and survival of the prawns during the first five-month postlarval period.

2.0 METHODS

The four diets tested consisted of (A) chick starter, (B) part chick starter and part shrimp grower, (C) shrimp grower and (D) part shrimp grower and part fish flesh. The chick starter diet consisted of 80% (by weight) Masterfeed chick starter bound with 10% agar and 10% gelatin to render it water stable. The protein content of the chick starter diet was 24%. The shrimp grower diet, obtained from Rangen Inc, had a protein content of 40%. The ingredients of the two commercial feeds are presented in Table 1. The fish flesh offered in diet D was fillets of white sucker (Catostomus commersoni). The portion of fish flesh offered was the equivalent in dry weight (water content of the fish flesh was 75-80%) to the portion of prawn pellets. The protein content of diets A, B, and C was 24, 32, and 40%, respectively. The protein content of diet D was not determined.

Fifty (50) four-week-old postlarvae with an average weight of 0.052 g were placed into each of 48 1.0 x 1.0 x 1.0 m mesh cages. The cages consisted of polyvinyl chloride frames covered with fly meshing on the sides and bottom. Three 1.0 x 0.2 m strips of fly mesh were suspended horizontally at different heights in the cages to provide additional surface area. The cages were placed

TABLE 1

INGREDIENTS OF COMMERCIAL FEEDS

Masterfeed Chick Starter		**Rangen Shrimp Grower**	
Crude protein (min)	20.0%	Crude protein (min)	40.0%
Crude fat (min)	3.0%	Crude fat (min)	4.0%
Crude fibre (max)	4.5%	Crude fibre (max)	5.0%
Vitamin A		Vitamin A	
Vitamin D		Vitamin D	
Vitamin E		Vitamin E	
Salt		Vitamin B12	
Calcium		Vitamin K3	
Phosphorous		Copper sulfate	
Selenium		Dicalcium-phosphate	
Amprolium (anti-coccidiosis)		Manganese sulfate	
		Potassium iodate	
		Sodium chloride	
		Zinc sulfate	
		Ethoxyquin (preservative)	

into two 7.2 x 6.0 x 1 m concrete pools equipped with circulating water heating systems (see Ontario Hydro Research Division Report No C85-12-K for description of water circulating system). Dechlorinated tap water was added to the pools through the water heating systems at a rate of 30 L/min resulting in a 10-day exchange rate. The pools were aerated continuously.

The mean monthly temperatures in the pools ranged from 27.6° to 29.1°C in pool 1 and from 27.9° to 28.4°C in pool 2. Daily (Mondays through Fridays) temperatures ranged from 20.5° to 30.3° C. Ammonium levels in the pools were generally less than 0.13 mg NH_3/L with the exception of a high concentration of 0.86 mg/L monitored when the aeration capacity was low. Ammonium levels monitored two weeks subsequent to the problem with the air supply were <0.01 mg/L.

The experiment consisted of 12 cages (50 prawns/cage) per diet, of which three randomly selected replicates were removed at four-week intervals over a 16-week period. The cages were placed in the pools in such a manner that the clustering of replicates was avoided. Replicates removed during a sampling interval were taken at random from the same pool such that variation due to possible differences in physical or chemical conditions in the pools was random.

The prawns were fed ad libitum once a day daily for the first month. For the remaining 12 weeks they were fed once a day Mondays through Fridays and were given double rations on Fridays to last the weekend. The animals on diet D were given part prawn pellets and part fish flesh three times a week and prawn pellets only on the remaining days. The cages were cleaned when excessive food built up.

Prawns within each cage were weighed collectively at the time of stocking and individually when the samples were removed from the experiment.

Separate analyses were performed on wet weight and dry weight data using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS) to determine whether there were significant differences (analysis of covariance, $P>0.05$) in the time trends, or growth curves, of the prawns on the four diets. The weights used in the analyses were adjusted for the baseline weights (Δ weights, ie weights at month 1, 2, 3 or 4 minus the weight at the start of the experiment) to account for the variation in the baseline weights. Dry weights were not determined for time 0. However, the dry weights were found to be highly correlated (correlation coefficient of 0.99) with wet weights. Therefore, the baseline dry weights were predicted using the linear regression equation

$$\ln(\text{dry weight}) = -1.357319 + 1.056408 \ln(\text{wet weight}).$$

The weights were ln transformed so that the data met the required assumption of homogeneity of variance. Duncan's multiple range test was used to determine which overall mean weights differed significantly ($P>0.05$).

A model was also developed using the GLM procedure of SAS to determine whether wet weight had a significant effect on survival. Analysis of variance was used to determine significance at the 0.05 level.

Detailed descriptions of the analyses used as well as the models derived are presented in Ontario Hydro Research Division Report No N85-2-K.

3.0 **RESULTS**

The animals reared on part prawn grower and part fish flesh attained the highest weight of 11.6 g at the end of the experiment followed in descending order by those raised on prawn grower alone, part chick starter and part prawn grower, and chick starter alone (Table 2). The average weights attained by the prawns raised on the latter three diets were 8.7, 6.6 and 4.6 g, respectively. A Duncan's multiple range test on the overall means (all four observation periods) of the wet weights indicated that they were significantly different from each other. The differences in weights were obvious at all four observation times and increased with time. Analysis of the wet weight data (Table 3) indicated that the time trends, or growth rates, of the prawns raised on the four diets were quadratic and significantly different from each other.

When the analyses were repeated using dry weights, which were highly correlated with the wet weights, the conclusions remained the same.

Only survival data collected up to the end of three months of experimental time is presented because a two-day failure of the water heating system during the fourth month resulted in significant mortality in the remaining replicates. At three months then, survival ranged from 56.7 to 74.7% with highest survival observed among animals reared on chick starter only and on prawn grower only while lowest survival was found among those reared on part chick starter and part prawn grower (Table 4). Data analysis (Table 5) indicated that wet weight did not have a significant effect on overall survival (all four observation periods). Since weight was found to be highly correlated with diet, the relationship between weight and survival was also indicative of the effect of diet on survival. Thus overall, diet did not have a significant effect on survival.

TABLE 2

MEAN WET WEIGHT (g) OF POSTLARVAL PRAWNS GROWN ON FOUR DIFFERENT DIETS

Diet	Experimental duration (Age of prawns in days postlarvae)				
	0 (28 days)	1 month (62 days)	2 month (90 days)	3 month (124 days)	4 month (152 days)
			g/prawn±SD[a]		
Chick starter	0.052±0.003	0.31±0.02	0.64±0.11	1.35±0.10	4.56±0.13
Chick starter/ prawn grower	0.053±0.004	0.35±0.08	1.40±0.23	3.85±0.07	6.60±1.24
Prawn grower	0.051±0.003	0.41±0.06	1.65±0.12	4.81±0.14	8.67±0.68
Prawn grower/ fish flesh	0.054±0.002	0.57±0.05	2.04±0.24	6.23±0.37	11.56±0.91

[a]Wet weights represent mean of three replicates ± standard deviation.

TABLE 3

WET WEIGHT ANALYSIS - GENERAL LINEAR MODELS PROCEDURE

Source	DF	Sum of Square	Mean Square	F-Value	PR>F	R-Square	C.V.
Model	11	70.806288	6.436935	492.99	0.0001	0.993587	20.0421
Error	35	0.456995	0.013057		Root MSE		LNDWT Mean
Corrected Total	46	71.263283			0.114267		0.570137

Source	DF	F-Value	PR>F
Diet	3	205.96	0.0001
Time	1	4657.87	0.0001
Time*Diet	3	3.83	0.0180
Timesq	1	64.31	0.0001
Timesq*Diet	3	23.77	0.0001

TABLE 4

SURVIVAL OF PRAWNS GROWN ON FOUR DIFFERENT DIETS

Diet	Experimental duration (Age of prawns in days postlarvae)		
	1 month (62 days)	2 month (90 days)	3 month (124 days)
	% Alive±SD[a]		
Chick starter	87.3±7.1	94.7±3.1	74.7±15.1
Chick starter/ prawn grower	84.0±12.5	88.0±7.2	56.7±5.0
Prawn grower	96.7±4.2	86.7±9.5	74.7±6.1
Prawn grower/ fish flesh	96.0±1.7	76.0±0.0	61.3±11.0

[a]Mean survival of three replicates ± standard deviation.

TABLE 5

SURVIVAL DATA ANALYSIS - GENERAL LINEAR MODEL PROCEDURE

Source	DF	Sum of Square	Mean Square	F-Value	PR>F	R-Square	C.V.
Model	8	1301.086818	162.635852	8.88	0.0001	0.724582	1.5169
Error	27	494.552071	18.316743		Root MSE		Surv Mean
Corrected Total	35	1795.638889			4.279806		40.694444

Source	DF	F-Value	PR>F
Time	2	26.92	0.0001
LNWet	1	3.46	0.0737
LNWet*Time	2	4.74	0.0172
LNWet*LNWet	1	0.96	0.3361
LNWet*LNWet*Time	2	1.65	0.2105

The ratio of food offered (dry weight) to the mean weight gain per cage (wet weight) at the end of the third month (see Appendix I) was 7.0 for the chick starter, 3.6 for the part chick starter and part prawn grower, 2.8 for the prawn grower and 2.7 for the part prawn grower and part fish flesh.

4.0 DISCUSSION

The best growth was obtained with the part prawn grower and part fish flesh diet followed by the diet consisting solely of prawn grower. The part chick starter and part prawn grower diet was next while chick starter alone produced the smallest animals. The weights attained by the prawns on the latter three diets increased with the protein content of the feed. However, although growth improved with protein content, it is not necessarily the only factor responsible for the enhanced growth since other differences in the diets existed as well.

The animals raised on both the chick starter and prawn grower apparently did not feed selectively since a preference for either of the feeds should have resulted in growth reflecting the results obtained with either feed alone.

The improvement of growth with the addition of fish flesh may be due to the presence of a growth factor in the fish flesh. Forster and Beard (1973 in New 1976) working on mussel nutrition suggested that such a growth factor, possibly steroid in nature, may be labile and destroyed or denatured by processing.

Growth on all four diets was better than that obtained in our first attempt at raising this species. Although poorest growth was obtained with the chick starter, the weights attained by the prawns on this diet were substantially better than that obtained during our previous attempt at rearing this species on chick starter. Maximum average weight of 21-week postlarvae was 1.48 g compared to the 4.56 g attained during the present study. Culture conditions during the two studies differed especially in terms of the culture medium. In the present study, the animals were contained in cages which had a common culture medium. Thus the culture medium contained leachates from all four diets which may have contributed either directly or indirectly to the nutrition of the animals fed the chick starter only resulting in the higher growth.

Generally, comparison of our results with those reported in the literature is difficult to make due to differences in culture conditions as well as diet. However, it is necessary to compare our results with that reported in the literature to determine whether the growth obtained on the test diets was comparable to those obtained by other culturists.

Hilton et al. (1984) using diets with protein content of 45 to 49% grew prawns aged 14-16 weeks to average weights of 2.0-2.8 g. If intermediate values between our second and third experimental month's data are considered for comparative purposes then the growth observed with the part chick starter and part prawn grower was within the range of that reported by Hilton et al. (1984) while that obtained with the prawn grower alone and the combination of prawn grower and fish flesh exceeded their range.

Boonyaratpalin and New (1982) who obtained favourable results in concrete ponds in Thailand using a simple, non-vitamin or mineral supplemented, 15% protein diet suggested that natural food present in non-earthen ponds with infrequent water change and well fertilized with formulated feeds has a significant effect on growth. The culture system used in the present study resembles that described by Boonyaratpalin and New (1982) in that we had a slow water turnover rate of ten days and a system fertilized with formulated feeds. Whereas Boonyaratpalin and New (1982) found that with these culture conditions growth was not enhanced with increased protein content of feed, our results indicated significant increases in growth with protein level. However, the natural productivity in their system was probably considerably higher than in ours since they had outdoor systems with less frequent water changes (three weeks). Another large difference was their stocking rate of $5/m^2$ compared to our $50/m^2$. The weights they reported for prawns of similar age to ours ranged from 10.9-20.6 g. Our best average weight fits into the lower end of their range.

Balazs and Ross (1976) raised Macrobrachium rosenbergii in outdoor fiberglass tanks in Hawaii on 15, 25 and 35% protein levels and two different major protein sources. Their stocking density was $17/m^2$. The higher protein content resulted in significantly larger animals although differences in protein source were not significant. The maximum average weight they reported at 244 days was 9.25 g with the growth rate of these animals described as equivalent to that achieved under pilot pond conditions. Our animals on the part prawn grower and part fish flesh achieved a higher average weight in a considerably shorter period.

Chick starter and Rangen prawn grower were among the commercial feeds tested by Stanley and Moore (1983) in their study on the growth of Macrobrachium rosenbergii placed in cages in Hawaiian culture ponds. These two feeds were among the four that resulted in the best growth. There were no statistical differences in the results obtained with the four diets. Animals 1.9 g at time of stocking reached average weights of 8.1-9.2 g following a 10-week experimental period. Assuming that their animals were approximately 90 days at time of stocking then their age would be comparable to ours at the end of our experiment. Thus the

average weight we obtained with the prawn grower alone was slightly higher than their lower value while that attained with the part prawn grower and part fish flesh diet exceeded their best growth.

Manik (1976) tested pelletized formulas containing ingredients available locally in Indonesia including different proportions of fish meal, soybean meal, rice bran, coconut oil cake, tapioca and Pfizer Premix A. The best weight attained by postlarvae of average weight 0.18 g stocked at 25/m^2 was 5.4 g following an 84-day experimental period. Assuming his animals were one month old at the start of the experiment, then the age of the animals would have been approximately 114 days at the end of the experiment in which case our best growth appears to be comparable to theirs.

Although culture conditions as well as diets differed, the growth obtained with the part prawn grower and part fish flesh was comparable to that reported in the above studies. Thus in our culture system this diet results in good growth. However, the growth attained on this diet is still substantially lower than that reported by Ling (1967) for Malaysian ponds with good water conditions and ample food. The average weight of Macrobrachium rosenbergii stocked into such ponds at 2.0 g (60-days postlarvae) was 25 g following a three-month growout period and 125 g after six months of growout. Apparently then the potential for further enhancement of our growth rates exists.

Analysis of the data indicated that weight did not have a significant effect on overall survival. Since weight was highly correlated with diet, the results were interpreted as indicating that overall survival was not related to diet. In their studies, Hilton et al. (1984), Boonyaratpalin and New (1982) and Balazs and Ross (1976) also found that survival was not related to diet.

Again, survival reported in the literature and obtained in our study is difficult to compare because of differences in culture conditions, especially stocking density, as well as differences in the age of the experimental animals and the experimental duration.

Survival of 66-77% over a 12-week period reported by Hilton et al. (1984) for animals stocked at age 2-4 weeks is comparable to our survival of 57-74% over 18 weeks and is generally lower than those reported for other studies conducted on diet. However, these studies had substantially lower stocking densities than used in Hilton et al. and our studies (40 and 50/m^2, respectively). Stanley and Moore (1983) had survival ranging from 74-88% while Balazs and Ross (1976) had survival of 90-98%. Boonyaratpalin and New (1982) had survival of 61-100% and Manik (1976) had survival of 86-100%. The stocking densities in these four studies ranged from 5 to 25/m^2.

With the relatively high stocking density used in our study the survival at the end of the experimental period resulted in comparable densities to those obtained by the above researchers who had lower stocking rates and higher survival. Perhaps future studies could concentrate on improving survival in intensive culture systems by increasing the surface area with the addition of artificial substrates as demonstrated by Smith and Sandifer (1975).

The ratio of food offered to the mean biomass gained per cage at the end of the third month ranged from 2.7 to 7.0. It is cautioned that differences in these ratios do not necessarily reflect differences in food conversion since the amounts of the feeds offered did not constitute a consistent percentage of the weights of the prawns. Thus differences in the ratios is probably more a reflection of this inconsistency than differences in food conversion. However, since the feed offered was excessive as indicated by the buildup of food in the cages, food conversion was probably less than the ratios presented. Thus food conversion efficiency of prawns reared on the part prawn grower and part fish flesh would be expected to be less than 2.7. The optimum daily ration for optimum growth and the gross conversion efficiency of the part prawn grower and part fish flesh diet would be required information before marketing proposals can be prepared.

5.0 SUMMARY AND CONCLUSIONS

1. Best growth was achieved by the prawns reared on part prawn grower and part fish flesh (11.6 g) followed in descending order by those raised on prawn grower alone (8.7 g), part chick starter and part prawn grower (6.6 g), and chick starter alone (4.6 g). The weights attained by the prawns on the latter three diets increased with protein content. The growth rates as well as the overall mean weights of the prawns raised on the four diets were found to be significantly different from each other.

2. The part prawn grower and part fish flesh diet resulted in good growth that was comparable to that reported in other studies on Macrobrachium rosenbergii diet. However, these growth rates were substantially lower than that reported for Malaysian ponds with good water conditions and ample food indicating that there is potential for further enhancement of our growth rates.

3. Overall survival was not significantly affected by diet.

4. Although survival was generally lower than those reported in other studies concerned with Macrobrachium rosenbergii diet

the resulting densities were comparable due to the low stocking rates used in those studies.

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APPENDIX I

RATIO OF FEED OFFERED (g DRY WEIGHT) TO BIOMASS GAINED (g WET WEIGHT)

Diet	(A) Dry Weight (g) of Feed Offered	(B) Wet Weight (g) of Biomass Gained	Ratio of A/B
Chick Starter	435.9	62.0	7.0
Part Chick Starter and Part Prawn Grower	602.4	166.9	3.6
Prawn Grower	576.5	206.0	2.8
Part Prawn Grower and Part Fish Flesh	622.7	234.2	2.7